B-1073
June 1968

Bermudagrass Production and Management *in East Texas*

TEXAS A&M UNIVERSITY
Texas Agricultural Experiment Station
H. O. Kunkel, Acting Director, College Station, Texas

Summary

Bermudagrass is an important forage plant in East Texas. It is best adapted to fertile loam and sandy loam soil, but will grow under a wide range of soil conditions. Several varieties of bermudagrass have been developed, and many of these have been tested for adaptation to East Texas. Coastal bermudagrass has shown the best performance in this area, producing 20 to 50 percent more forage than Common bermudagrass. Other varieties have been tested and are satisfactory, but are not superior to Coastal. These include Midland, Suwannee and Selection No. 3. NK-37, a seeded variety, was inferior to Coastal in a test conducted in 1960 and 1961. Coastcross-I, which was released from Georgia in 1967, has not been evaluated.

Coastal bermuda responds favorably to nitrogen fertilization, interplanted winter legumes and a combination of these two practices. Coastal responded favorably to applications of 200 or more pounds of nitrogen per acre per year. Both phosphorus and potassium are needed for sustained production of bermudagrass. Lime also is required, especially if 200 pounds or more of nitrogen are used annually. The practice of overseeding an adapted winter legume increased total forage production about as much as 60 pounds of nitrogen per acre without the legume. Coastal bermuda, overseeded in the fall with crimson clover and fertilized with 120 to 150 pounds of nitrogen per acre beginning approximately June 1, has produced 5 to 6 tons of forage annually. This amount of nitrogen without the legume produced 4 to 4.5 tons of forage. The use of the legume without nitrogen produced about 3.75 tons annually. The legume results in earlier forage production than Coastal without the legume. The best practice seems to be, therefore, a combination of a winter legume followed by nitrogen applications that begin approximately at the time the legume matures.

The peak of forage production is influenced to some extent by the time of nitrogen application. Production can be shifted by delaying the time of initial nitrogen application. However, late summer and early fall growth is poor, and response to late nitrogen applications is less than to spring applications.

Defoliation practices are known to affect both the yield and stand survival of forage plants. In a 5-year study involving the effects of clipping practices and fertility levels on Coastal bermudagrass, yields were greater with a short stubble height (2 inches), infrequent harvest (14 to 16 inches of growth) and nitrogen fertilization (240 pounds of nitrogen per acre). Yields were almost as great with intermediate harvest frequency (8-10 inches of growth or 3 to 4 weeks) as with infrequent harvest. Yield and ground cover density increased with nitrogen fertilization and with each succeeding year of the study. Root weight was not influenced by nitrogen fertilization and declined in each succeeding year of the study. Ground cover increase and root weight decline were slightly greater with close, frequent defoliation, but neither the density nor the root weight changes were related to yields. Differences in carbohydrate content of both stems and rhizomes were detectable immediately following clipping, but no permanent or major sustained treatment effects were found. Height of cutting appears to be less important in Coastal bermudagrass production than either frequency of defoliation or level of fertilization, but Coastal bermudagrass will tolerate a wide range in both height and frequency of defoliation.

Contents

Summary 2
Introduction 3
Bermudagrass Varieties 3
Performance of Bermudagrass Varieties 4
Bermudagrass-Legume Combinations 6
Fertilization 6
Nitrogen Rates 6
Time of Nitrogen Application 7
Fertilization and Legume Combinations 8
Coastal Bermudagrass Management 9
Forage Yields 9
Protein Content 10
Root Weights and Stand Density 10
Carbohydrate Content 12
Soil Temperature 13
Literature Cited 15

Bermudagrass Production and Management

in East Texas

Ethan C. Holt and J. A. Lancaster*

Bermudagrass is the most important pasture grass in East Texas. Bermudagrass will grow on most soils, but it does best on fertile loam and sandy loam soils. It can be grown satisfactorily on the light sandy soils of East Texas provided adequate fertility is supplied.

Bermudagrass is a long-lived perennial with a spreading growth habit and reproduces by runners, rootstocks and seed. The runners vary in length from a few inches to 3 or 4 feet, and the seed heads usually attain a height of 6 to 12 inches or more, depending on soil productivity. Figure 1 shows a typical improved pasture made by Common bermudagrass.

Coastal bermudagrass, which is vegetatively more productive than Common bermudagrass and better adapted to hay making, has increased in acreage tremendously in recent years in this area. Coastal can produce 20 to 50 percent more forage than Common and perhaps even more under certain conditions. Improved management practices, including proper use of legumes and fertilizers, are necessary if the potential of Coastal is to be realized. This publication summarizes the results of several studies involving varieties and yield responses to various management practices.

BERMUDAGRASS VARIETIES

Several varieties and strains of bermudagrass have been developed in recent years. The first and most important of these, from a use standpoint, is Coastal. Coastal, which is a hybrid, was developed at the Georgia Coastal Plain Experiment Station by crossing Tift bermuda with a bermudagrass introduced from South Africa. Coastal has larger stems, stolons, rhizomes and longer internodes than Common bermuda (1). It is characteristically a lighter green than Common and produces few seedheads which rarely contain viable seed; therefore, it must be propagated vegetatively. The growth characteristics of Coastal are shown in Figure 2.

Selection No. 3 bermudagrass also was produced at the Georgia Coastal Plain Experiment Station and resulted from the same cross that produced Coastal. Selection No. 3 has shorter internodes, a darker green color and denser growth than Coastal. Work in Georgia indicated that it was less palatable than Coastal and several other selections (2). Its forage production generally is equal to or greater than that of Coastal.

Midland bermudagrass was developed in Georgia as a hybrid between Coastal and a cold-hardy variety from Indiana (3). Midland has somewhat less desirable forage than Coastal, but is much more winter hardy. Midland is palatable, has good disease resistance and does not produce as many seedheads as most

*Respectively, professor, Department of Soil and Crop Sciences; and associate agronomist, East Texas Research and Extension Center, Overton, Texas.

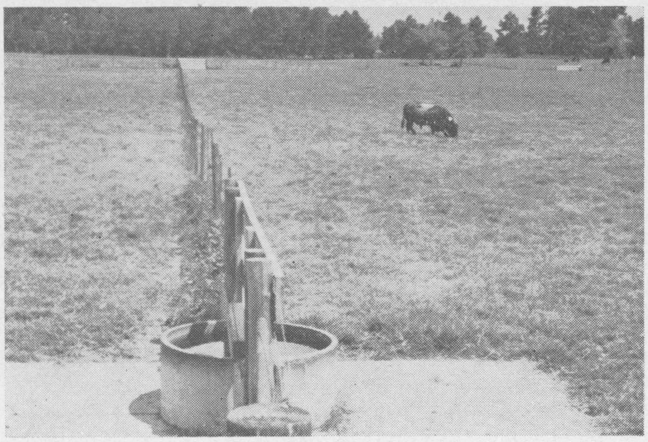

Figure 1. Typical improved pasture of Common bermudagrass in East Texas.

common types of bermudagrass. Midland was released and named by the Oklahoma Agricultural Experiment Station for areas where Coastal is not winter hardy. The Oklahoma Station reports that Midland is two to four times as productive as unselected Common bermuda on fertile soils. It is reported also as being a better companion crop for legumes than Common because it has fewer rootstocks.

Suwannee bermudagrass was released in 1953 by the Georgia Coastal Plain Experiment Station for use on deep sands (4). Suwannee is palatable and resists diseases, frost and drouth. It is a hybrid, produced from the same cross that resulted in Coastal, and grows tall enough to be cut for hay or silage. In some tests in Georgia, it has produced from 10 to 20 percent more forage than Coastal on drouthy, sandy soils with low levels of applied fertilizer. It has shown no superiority to Coastal, however, on sandy soils in East Texas.

NK-37 bermudagrass was released by the Northup-King Company as an erect giant bermuda that can be reproduced by seed. Its erect growth makes it suitable for hay production. NK-37 makes rapid growth in the spring following establishment, but generally produces less total growth than vegetative varieties. Also, NK-37 does not persist as well as Common bermudagrass. It is susceptible to leaf diseases which reduce its vigor in years when leaf disease attacks are severe. WS-300 bermudagrass is a Whitman Seed Company variety with description similar to NK-37. It has not been observed in this area.

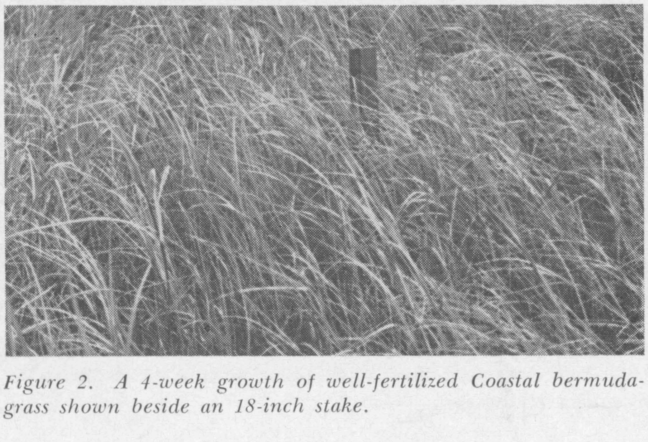

Figure 2. A 4-week growth of well-fertilized Coastal bermudagrass shown beside an 18-inch stake.

Coastcross-I is a new hybrid released in 1967 from the Coastal Plain Experiment Station, Tifton, Georgia. Coastcross-I resulted from a cross between Coastal bermudagrass and a plant introduction (255445) from Kenya, South Africa. Coastcross-I is completely sterile, grows taller and has broader leaves than Coastal. It has spreading stolons, but few, if any, rhizomes. It is highly resistant to foliage diseases and sting nematode. Its yield is slightly below Coastal, but it has consistently been 11 to 12 percent higher in digestibility than Coastal, based on the nylon bag technique. Coastcross-I spreads faster and becomes established quicker than Coastal and makes more fall growth, but it is less winter hardy than Coastal.

Zimmerly Select was introduced from Northern Rhodesia, Africa, through the U. S. Department of Agriculture Plant Introduction Program in 1955 as P.I. 224693. This plant introduction is known in some localities as "Zimmerly Select" bermudagrass. P.I. 224693 is the same genus and species as Common and Coastal bermudagrass, but different from Africa Stargrass. It spreads by both rhizomes and stolons. Trial plantings in Texas starting in 1966 indicate that Zimmerly Select produces slightly less forage than Coastal, and its rate of spread is about the same or slightly less than Coastal. It seems to have more erect stems and leaves and to produce more seed heads under certain stress conditions than Coastal. Zimmerly Select has not been subjected to experimental grazing, and no animal response data are available. Research in Louisiana showed the protein content pattern from spring to fall to be similar to that of Coastal.

PERFORMANCE OF BERMUDAGRASS VARIETIES

Most of the varieties described in the preceding section have been evaluated in small-plot clipping studies in East Texas, but not all of them have been evaluated in any one study. The results of a study started in 1956 at Mt. Pleasant are summarized in Table 1. The yield results by harvest periods for 1959 and the annual total yields by years are given. The plots were fertilized with 0-60-60 each fall and 30-0-0 following each clipping, giving an annual total fertilization of 120-60-60 most years. Selection No. 3 produced more forage than Coastal most years. The denser and shorter growth of Selection No. 3 compared with Coastal makes it a less desirable hay plant. This, combined with its lower palatability, probably offset any yield advantage of this strain over Coastal (2).

Table 1. Forage yield of bermudagrass varieties at Mt. Pleasant, Texas, by harvest periods, 1959 and total annual yields, 1956-59

Variety	May 28 (1959)	June 29 (1959)	Aug. 3 (1959)	Sept. 1 (1959)	Sept. 29 (1959)	Total (1959)
	Tons of air-dry forage per acre					
Selection No. 3	1.35	1.05	1.18	0.55	0.63	4.77
Coastal	1.02	1.05	0.88	0.67	0.47	4.10
Suwannee	0.84	1.10	0.86	0.60	0.56	3.98
Common	0.61	1.22	0.88	0.45	0.53	3.69

Variety	1956	1957	1958	1959	Average
	1956-59				
Selection No. 3	1.85	5.55	7.83	4.77	5.03
Coastal	2.07	5.11	7.21	4.10	4.63
Suwannee	2.64	3.75	7.13	3.98	4.25
Common	1.07	4.18	6.83	3.69	3.94
LSD (.05)	0.69	0.87	0.64	0.48	

Suwannee produced more forage than Coastal the first year of the test, which indicates that it became established more rapidly. It did not produce as much as Coastal after 1956. These results indicate no advantage gained by growing Suwannee rather than Coastal or No. 3.

A test was started in 1959 which included Midland bermuda as well as Suwannee, and in 1960 NK-37 was added. Yield results for 3 years are summarized in Table 2. The test area was sprigged May 1, 1959, and on July 24 more than 2 tons of hay per acre were harvested from Midland and more than 1½ tons from Coastal and Suwannee. These results indicate that these vegetatively propagated varieties are rapidly established.

Midland produced about 0.6 tons more forage than Coastal in 1959, mainly because it became rapidly established, but it produced slightly less forage in 1960 and 1961. Suwannee produced less forage than either Coastal or Common during the 3 years of this study.

NK-37 was seeded on April 25, 1960. It became established very rapidly, producing 2,600 pounds of forage per acre by July 1. The established grasses were harvested the second time when NK-37 was harvested the first time. However, the vegetative varieties produced significantly more than NK-37, omitting the first cutting. This may not be a fair comparison, since NK-37 was in its seedling year, but it became well established as indicated by the initial growth. Also, NK-37 produced less forage in 1961 than in 1960, whereas all other varieties increased in 1961. NK-37 and these varieties were planted in 1959 in a test near Kirbyville, and NK-37 produced significantly less forage than the other varieties.

Table 2. Forage yield of bermudagrass varieties at Mt. Pleasant, Texas, 1959-60

Variety	1959	1960	1961	Average
	Tons of air-dry forage per acre			
Midland	4.95	6.40	6.89	6.08
Coastal	4.32	6.58	6.99	5.96
Selection No. 3	4.35	6.40	6.81	5.85
Common	3.72	4.85	5.51	4.69
Suwannee	3.20	4.29	4.73	4.07
NK-37[1]		2.80	2.00	2.40
LSD (.05)	1.12	0.75	0.72	

[1]NK-37 seeded in the spring of 1960.

Table 3. Forage yield of bermudagrass varieties on very deep sand near Mt. Pleasant, Texas, 1958-60

Variety	1958	1959	1960	Average
	Tons of air-dry forage per acre			
Coastal	3.37	4.02	5.01	4.30
Suwannee	3.04	3.53	4.16	3.57
Common	2.78	2.94	2.55	2.76
LSD (.05)	N.S.	1.02	1.66	1.22

Suwannee was compared with Coastal and Common on very deep sand near Mt. Pleasant during 1958-60. This study received a 60-60-60 fertilizer in 1958 and 150-60-60 in succeeding years. The results presented in Table 3 indicate that the performance of Suwannee relative to Coastal and Common was better than in the earlier test, but its actual yield was below Coastal.

The results of these tests indicate that Coastal is well adapted to the East Texas area. The performance of Midland was satisfactory, but it is not recommended as a replacement for Coastal. The performances of Suwannee and NK-37 were inferior to Coastal and Midland.

A test involving two varieties not previously evaluated was started near Mt. Pleasant in 1965. The test was re-established at the new research location near Overton in 1966. It is apparent from the 1965 and 1966 data in Table 4 that neither Zimmerly Select nor the San Antonio Selection became established more rapidly than Coastal. In the second year of the Overton study, Coastal was superior in yield to the other varieties.

Table 4. Forage yields of bermudagrass varieties in East Texas

Variety	1965[1]	1966[2]	1967[2]
	Tons of air-dry forage per acre		
Coastal	2.70 a	0.59 a	5.57 a
Zimmerly Selection	2.25 ab	0.53 a	4.61 b
San Antonio Selection	1.92 b	0.54 a	5.14 ab
Common	1.27 c	0.37 b	2.09 c

[1]First-year planting near Mt. Pleasant.

[2]Planted April 20, 1966, near Overton.

BERMUDAGRASS-LEGUME COMBINATIONS

Various winter-annual legumes were evaluated in combination with Coastal bermudagrass on a light sandy soil near Mt. Pleasant. Legume establishment on Coastal is sometimes difficult and poor, especially in the Southern half of the Coastal growing area. A good grass-legume combination just before maturity of the legume is shown in Figure 3. Some of the legumes made good growth and resulted in earlier production than Coastal without a legume, since Coastal grows very little in this area before mid-April. Studies reported later in this publication show that a combination of legume on Coastal followed by nitrogen applications starting about June gives the best total production and also the longest production season.

The best adapted legumes of those tested appear to be crimson clover, narrow leaf vetch and Singletary peas. Narrow-leaf vetch, *Vicia angustifolia,* is a native plant in East Texas which shows some promise when used on permanent sod. Once established it reseeds even under grazing, but commercial seed are not available because mature seed are extremely difficult to harvest.

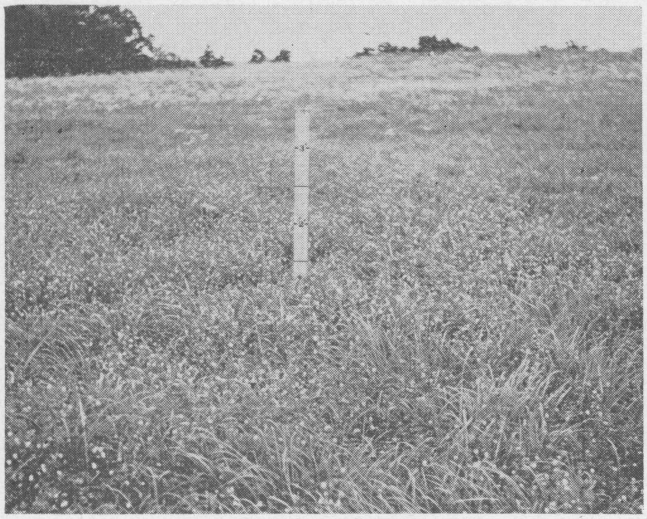

Figure 3. Grass and legume combination in East Texas.

Singletary peas have been used to some extent in sod, but the plant is not as well adapted for forage as crimson clover. For this reason crimson clover was used in most of the later studies with Coastal bermudagrass reported in this publication.

FERTILIZATION

Nitrogen Rates

Coastal bermudagrass responds to high rates of fertilization with the response being limited mainly by available light and moisture. A study was conducted in East Texas near Mt. Pleasant to determine the response of Coastal to fertilization without supplemental irrigation. A plot area was established in April 1960. The area was fertilized at planting with 30-60-60 followed by 30-0-0 in early June. Crimson clover was broadcast on all plots in early October 1960 and each fall thereafter. Nitrogen, phosphorus and potassium at the rates and combinations shown in Table 5 were applied each year beginning in 1961. The phosphorus and potassium were divided into two increments, the first half being applied in October each year and the second half in early March. Nitrogen application, in the form of ammonium nitrate, began on June 1 with four split applications following the first four Coastal clippings on these approximate dates: 1/3 (June 1); 1/3 (July 1); 1/6 (Aug. 1); 1/6 (Sept. 1). Clippings before May 15 contained varying amounts of crimson clover. The plots were cut five to seven times each year at approximately a 2-inch stubble height.

Total forage yields for each of the three years and the averages are given in Table 5. Crimson clover

Table 5. Forage yield of Coastal bermudagrass as influenced by rates and ratios of nitrogen, phosphorus and potassium

Pounds per acre			Tons of air-dry forage per acre			
N	P_2O_5	K_2O	1961	1962	1963	Average
0	0	0	3.22	3.34 f	2.83 g	3.13
0	200	200	3.38	3.33 f	1.92 g	2.88
200	100	100	7.46	6.27 cde	7.05 bcd	6.93
200	100	200	7.79	6.54 cde	5.82 de	6.72
200	200	100	7.91	6.86 bcde	7.75 ab	7.51
200	200	200	7.86	7.38 abc	6.95 bc	7.40
400	0	200	7.43	6.18 cde	5.21 ef	6.27
400	50	200	7.65	7.27 abc	7.60 ab	7.51
400	100	100	7.44	6.51 cde	6.76 bcd	6.90
400	100	200	7.91	6.95 bcd	6.94 bc	7.27
400	200	0	7.76	5.55 e	4.16 f	5.82
400	200	100	7.89	7.47 abc	7.56 ab	7.64
400	200	200	8.29	8.42 a	8.57 a	8.43
600	200	200	8.28	7.45 abc	8.51 a	8.08
800	200	200	8.23	7.36 abc	7.69 ab	7.76

Values with a common letter designation do not differ significantly (.05) level. Duncan's Multiple Range.

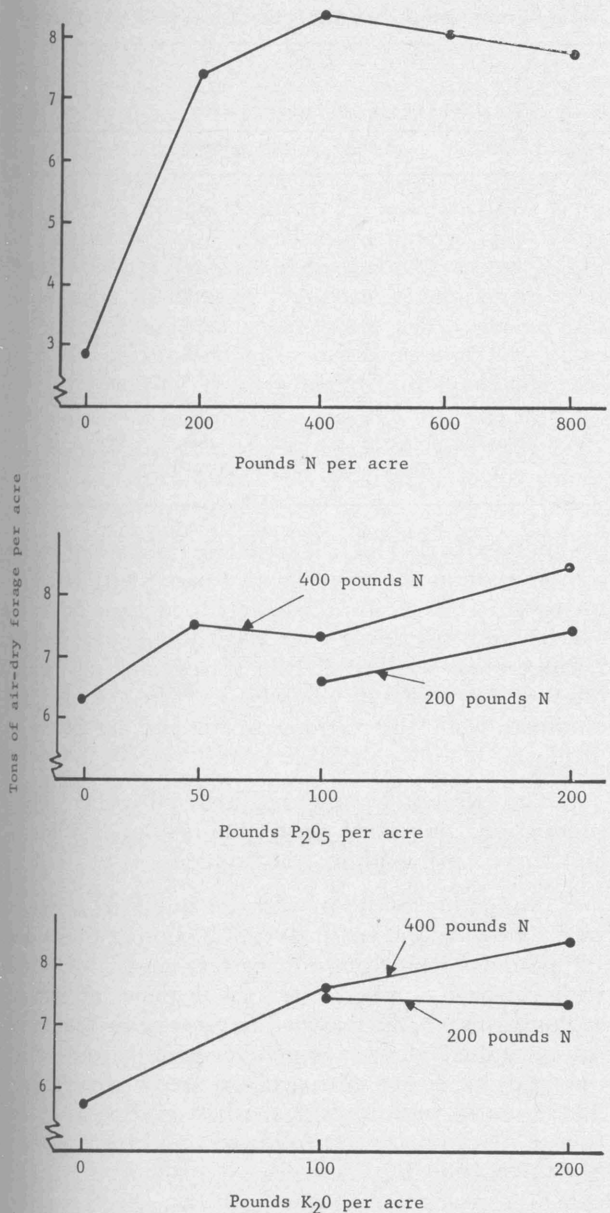

Figure 4. Coastal bermudagrass yields as influenced by varying fertilizer levels of N, P or K in the presence of constant rates of other fertilizer elements (200 pounds of P_2O_5 and/or K_2O).

yields were poor and influenced total yield very little except with zero nitrogen rates. Approximately ⅓ of the yield on zero nitrogen consisted of crimson clover.

Yields decreased each year in the absence of nitrogen, phosphorus or potash, but remained relatively constant where all three fertilizer elements were applied. Approximately 7 tons of hay were produced with 200 pounds of N, whereas yields declined above 400 pounds of N, (Figure 4). Responses to phosphorus and potassium levels are shown graphically in Figure 4.

In general, the response to applied phosphorus and potassium increased with higher rates of nitrogen.

Soil samples were collected at the end of the second year from all nitrogen plots receiving 200 pounds each of P_2O_5 and K_2O. Results of the soil analysis are presented in Table 6. Organic matter, phosphorus and soluble salts remained fairly constant at all nitrogen rates while pH, potassium and calcium steadily decreased. Most of the potassium decrease occurred with the first 200 pounds of nitrogen and may be accounted for largely by uptake in the 4 tons of growth produced by the nitrogen. However, it is likely that potassium leaching also occurred. The decrease in calcium in the upper level of the soil profile is of concern mainly because of the change in pH and may dictate correction through the use of lime.

The results of this study suggest the use of at least a 200-50-100 fertilizer. The use of a ton of lime every 3 years appears advisable. Additional phosphorus and potassium may be needed if conditions warrant the use of higher rates of nitrogen. Such conditions might include high production under irrigation and maintenance of high levels of crude protein. Periodic soil analysis might also indicate further alterations in the fertilizer regime.

Time of Nitrogen Application

A study of the effect of time and rate of nitrogen application on a crimson clover-Coastal bermudagrass combination was started in 1957. A well-established block of Coastal bermudagrass was fertilized with 0-60-60 in the fall of 1956 and overseeded with crimson clover. This practice was followed each fall. Nitrogen rates of 0, 60, 90 and 120 pounds per acre were applied in two, three or four applications beginning in May and also in June each year. The initial application was made approximately May 1 with one set of treatments and delayed until June 1 with a second set to permit legume maturity.

Table 6. Soil analysis from plots receiving 0-200-200 fertilization in addition to nitrogen

	Soil analysis					
Pounds N applied per acre	pH	O.M. (percent)	P_2O_5 (pounds per acre)	K_2O (pounds per acre)	CaO (pounds per acre)	Soluble salts (pounds per acre)
0	6.4	0.8	18	292	1,736	432
200	5.7	1.0	24	106	748	120
400	5.3	0.8	16	96	476	120
600	5.2	0.8	24	96	392	240
800	5.3	0.9	32	88	308	120

Table 7. Influence of nitrogen amount and application time on Coastal bermudagrass, Mt. Pleasant, Texas, 1957-60

Treatment		Total tons of air-dry forage per acre				
Total pounds N per acre	Time of application of each increment	1957	1958	1959	1960	1958-60
120	May, June	3.05	5.57	6.53	5.50	5.87
120	May, June, July, August	3.99	5.88	6.52	6.72	6.21
90	May, June, July	3.58	5.18	6.08	5.58	5.61
60	May, June	2.39	4.63	5.99	4.81	5.14
Average		3.13	5.31	6.28	5.53	5.71
120	June, July	4.14	4.94	6.06	6.24	5.75
120	June, July, August, September	3.94	6.11	6.45	5.38	5.98
90	June, July, August	3.34	5.38	6.18	5.21	5.59
60	June, July	3.09	4.67	5.55	5.18	5.13
Average		3.63	5.48	6.06	5.50	5.61
No nitrogen		2.08	3.43	4.35	4.09	3.96
LSD (.05)		0.59	0.50	0.51	0.51	0.50

The results of this study are summarized in Table 7. Good yields were obtained in 1958, 1959 and 1960 and fair yields in 1957, which was the first year of the test. Forage yields increased more than 1 ton with 60 pounds of nitrogen. With an additional 30 pounds of nitrogen, yields increased 0.45 tons or more; and with the final increment of 30 pounds, yields went up another 0.35 tons.

The initial nitrogen application date did not significantly influence total yields, but it did influence time of production. Initial applications earlier in the spring might give greater response in years when a moisture deficit is encountered in mid-summer. May production definitely was higher when nitrogen applications were started May 1. Plots receiving nitrogen about August 1 produced more forage in August than other plots even though moisture was limited during that month. September production was favored only slightly by a September nitrogen application.

Good production on plots that received no nitrogen is attributed to fall fertilization with 0-60-60 and the winter legume. These results indicate that nitrogen may be used economically in combination with a summer grass-winter legume combination. Maximum production was not reached with 120 pounds of nitrogen. This was shown by the 0.35 ton increase in forage when nitrogen was raised from 90 to 120 pounds per acre, thus indicating that higher rates might be used effectively. The fertilizer study reported in the previous section, but conducted later, verifies the suggestion of additional nitrogen. The potassium level in this study also was below that indicated by the fertilizer study, but the fertilizer study did not include rates between 0 and 100 pounds of K_2O per acre. It is likely that 60 pounds of K_2O is adequate at the levels of nitrogen used in this study.

Fertilization and Legume Combinations

A study was started in the fall of 1958 to determine both the total forage production and the production period of a Coastal bermuda and clover combination as contrasted with Coastal fertilized with nitrogen. The Coastal was fertilized each fall with 0-60-60 and crimson clover seeded on certain plots. Nitrogen was applied in the spring and summer at rates of 90 and 120 pounds per acre. Yield data obtained from the various treatments are given in Table 8.

The winter legume resulted in earlier forage production; no yields were obtained in late March and early April without the legume.

Production without nitrogen but with a legume was almost as successful as production with 90 and 120 pounds of nitrogen on Coastal alone. Production with nitrogen applied after the legume, or starting around June 1, increased 1.5 tons more than with nitrogen used alone. September growth was not influenced by either nitrogen or the winter legume. These results indicate that the best practice is utilization of a winter legume followed by nitrogen starting May 1 to June 1.

Table 8. Forage yield of Coastal bermudagrass as influenced by winter legume and nitrogen treatments, Mt. Pleasant, Texas, 1958-60

Treatment			Tons of air-dry forage per acre			
Legume	Nitrogen, pounds per acre	Date of nitrogen application	1958	1959	1960	Average
Legume			3.78	3.89	3.71	3.79
Legume	60	June 1				
	60	July 1	5.71	5.88	5.76	5.78
Legume	30	June 1				
	30	July 1				
	30	August 1	5.44	5.57	5.54	5.50
No legume	60	May 1				
	60	June 1	4.29	4.37	3.57	4.08
No legume	30	May 1				
	30	June 1				
	30	July 1	3.92	4.17	4.46	4.18
LSD (.05)			0.57	0.94	0.80	

COASTAL BERMUDAGRASS MANAGEMENT

Coastal bermudagrass is widely used as a pasture and hay plant in East Texas. Numerous studies have been conducted on the response of Coastal to fertilization and harvest frequency in terms of both forage yield and quality, but relatively little emphasis has been placed on stand maintenance and sustained vigor in these studies. Neither has height of cutting received major attention, likely because Coastal is a rhizomatous sod-forming plant which seldom presents major problems in stand survival. However, ground cover may be important for other reasons, and plant residual following cutting could influence vigor as well as longevity.

A study was conducted at Mt. Pleasant from 1961 to 1965 to evaluate the effects of clipping management practices and nitrogen level on sustained vigor as indicated by yield, ground cover and root accumulation.

A block of Coastal bermudagrass was established on April 4, 1961, on Sawyer fine sandy loam soil. A management study consisting of three clipping frequencies, two clipping heights and two nitrogen levels in all combinations was initiated as soon as a ground cover was established. Clipping frequencies, based on the amount of growth, were 2-4 inches, 8-10 inches and 14-16 inches. These corresponded to approximately 2, 4 and 6-week intervals; clipping (stubble) heights were 2 and 5 inches; nitrogen rates were 120 and 240 pounds per acre. In addition, two zero nitrogen treatments were included and cut at 2 and 5-inch stubble heights when 8-10 inches of growth was made.

All plots were fertilized with 0-60-60 at establishment and in October of each year. In addition, all plots were cut to a uniform 2-inch stubble height at the end of the growing season and overseeded with crimson clover. The initial harvest each spring, usually about May 1, consisted almost entirely of crimson clover and was made at a uniform 2-inch height. Differential cutting heights were initiated with the bermudagrass growth in May. Nitrogen was applied in split applications following harvest of the crimson clover. The 2-4-inch and 8-10-inch clipping frequency received nitrogen after the first four clippings, while the 14-16-inch frequency received only three applications. Each application consisted of either 30 or 60 pounds when four applications were used and 40 or 80 when three applications were used, totaling 120 and 240 pounds of N per acre annually. Following 4 years of the above treatments, all plots were treated and harvested uniformly in the fifth year to evaluate cumulative treatment effects.

Ground cover density was determined by making stem counts in duplicate square foot samples located at random in each plot at the time of the first bermudagrass clipping each spring and immediately following the final clipping each fall. At the same time, stem (stubble) samples and root samples taken to a depth of 18 inches using a 2-inch tube were obtained from each plot of selected treatments. Sample treatments consisted of combinations of 120 pounds of N per acre, 2 and 5-inch stubble height and 2-4 and 14-16-inch clipping frequency. Three samples per plot were taken and composited. Root samples were washed, dried and weighed with no attempt being made to separate live and dead tissue. Composites of the total root samples and stem samples of each treatment were analyzed for soluble carbohydrates and starch in 1964. In addition, root and stem samples were collected in July 1964 from the selected treatments at the time of clipping and 4, 11 and 18 days later. A high percentage of the root sample was made up of rhizomes. Ethanol soluble reducing sugars were determined by the Wildman and Hanson method (5). The non-soluble residue remaining after Soxhlet extraction was submitted to initial hydrolysis by Takadiastase and subsequent hydrolysis by HCl. Reducing sugars were then determined with modifications on this residue by the method described above and all fractions totaled and reported as total soluble carbohydrates. Density counts and root sample weights determined in the spring are not reported because treatment differences were small and nonsignificant.

All data except total carbohydrate percentages were subjected to various analyses. Chemical analyses were based on composite samples and could not be analyzed statistically. Treatments resulting in statistical significance are indicated in footnotes, but actual differences required for significance are not presented, since the number of values for comparison in each case is small.

Total rainfall during the 4 months, June to September, was relatively uniform, ranging from approximately 13 to 15 inches. Total annual rainfall varied from less than 32 to 48 inches.

Forage Yields

Average yields of Coastal bermudagrass during the 4-year period of the study are presented in Table 9.

Table 9. Forage yield of Coastal bermudagrass with various treatments, 1961-64

Inches of top growth at harvest	Clipping height (inches)	Tons air-dry forage per acre (4-year averages)			
		Pounds N per acre			Average
		0	120	240	
2-4	2		4.6	5.9	5.2
	5		4.5	5.4	4.9
Average			4.5	5.7	5.1
8-10	2	2.4	5.7	6.9	6.3
	5	2.0	4.5	6.1	5.3
Average			5.1	6.5	5.8
14-16	2		6.1	7.5	6.8
	5		5.2	6.1	5.6
Average			5.6	6.8	6.2
Nitrogen average		2.2	5.1	6.3	

Height average: 2 inches—6.1 tons, 5 inches—5.3 tons.

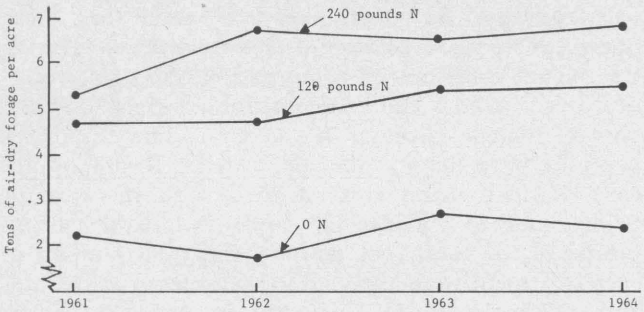

Figure 5. Forage yield of Coastal bermudagrass as influenced by nitrogen level.

The first increment of nitrogen increased yields on the average 2.9 tons per acre per year, while the second increment increased yields 1.2 tons per acre. Other benefits, such as increased protein content and density, occurred with the second increment of N, leaving no doubt as to the value of the additional nitrogen.

Average yields of Coastal increased with each delay in harvest or with more advanced stages of maturity. The greater increase, 0.7 tons, occurred between harvesting 2-4 inches of growth and 8-10 inches of growth. Increasing the height of cut or stubble residue from 2 to 5 inches decreased yields 0.8 tons per acre. The effect of stubble height showed some interaction with both fertility level and clipping frequency. The difference in yield between the two stubble heights was only 0.1 tons with 120 pounds of N and frequent harvest. This difference increased to 1.4 tons with 240 pounds of N and the least frequent harvest.

Average yields with the three nitrogen levels for each year of the study are shown graphically in Figure 5. Response to the highest level of nitrogen was less the first year than in succeeding years, possibly because of the shorter season in the establishment year. Although total rainfall varied considerably from year to year, both the total yields and response to nitrogen were fairly consistent after the first year.

The yield response to differential clipping treatments and years is shown in Figure 6. The infrequent harvest (14-16-inch regrowth) showed somewhat erratic behavior. However, following the initial year, yield with the two cutting heights and infrequent harvesting followed the same pattern. No major trends

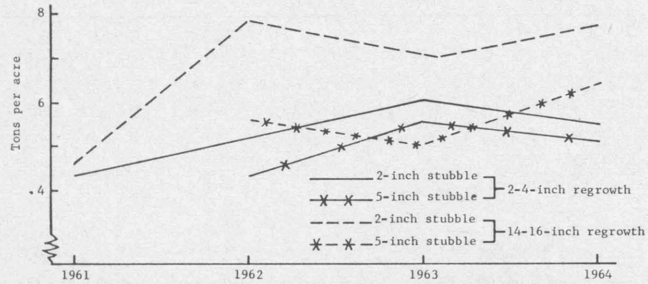

Figure 6. Forage yield of Coastal bermudagrass, Mt. Pleasant.

Table 10. Average crude protein content of Coastal bermudagrass, Mt. Pleasant, 1961-64

Fertilization	Amount of growth at harvest (inches)	Weighted averages[1] (percent) 1961	1962	1963	1964	Average
120-60-60	2-4	13.6	10.8	12.4	14.1	12.7
	8-10	12.5	7.9	10.1	11.2	10.4
	14-16	11.5	6.6	7.0	7.5	7.9
Average		12.5	8.0	9.6	10.4	10.1
240-60-60	2-4	17.9	12.4	14.8	15.2	15.0
	8-10	15.3	11.3	11.6	13.8	12.8
	14-16	16.1	9.0	9.4	10.7	10.8
Average		16.3	10.6	11.8	12.9	12.7

[1]Individual harvests were analyzed, but yield per harvest and percent protein by harvest were used in calculating weighted averages.

suggesting changes in plant vigor are apparent. The reduced yield of the frequent harvest (2-4-inch regrowth) in 1964 could be assumed to be a trend, but had the test been terminated in 1963, the same conclusion could have applied to the infrequent harvest.

Protein Content

Average crude protein content of the harvested forage is shown in Table 10. Protein content increased 2.5 to 3 percent with the heavier nitrogen rate and decreased 2 to 3 percent with each delay in harvest or more advanced stage of maturity. Stubble height did not influence protein content of the harvested forage, thus the stubble heights are not shown. Seasonal differences in crude protein content are shown in Figure 7. Obviously both nitrogen level and stage of maturity at harvest are important. A protein content of 12 to 15 percent was maintained with 240 pounds of nitrogen per acre and harvesting 8-10 inches of growth.

Root Weights and Stand Density

Root accumulation and stand density are important for two reasons. They reflect the general vigor and potential productivity of the stand and provide protection to the soil. Changes in either root accumulation or stand density may be noted before yields are actually affected and thus might

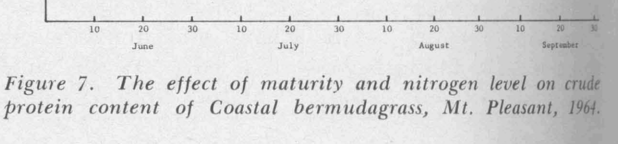

Figure 7. The effect of maturity and nitrogen level on crude protein content of Coastal bermudagrass, Mt. Pleasant, 1964.

Table 11. Weight of Coastal bermudagrass roots with various fertilizer and clipping management practices, Mt. Pleasant, Texas, 3-year summary, 1962-64

Inches of top growth at harvest	Clipping height (inches)	Tons of roots per acre							
		120-60-60				240-60-60			
		1962	1963	1964	Average	1962	1963	1964	Average
2-4	2	5.92	4.00	2.62	4.18	6.70	4.29	2.06	4.35
	5	6.97	5.09	3.43	5.16	6.22	6.01	3.17	5.13
Average		6.45	4.55	3.02	4.67	6.46	5.15	2.61	4.74
8-10	2	5.00	3.10	3.03	3.71	5.33	4.05	2.24	3.87
	5	5.92	6.30	2.12	4.78	5.59	4.39	2.68	4.22
Average		5.46	4.70	2.57	4.24	5.46	4.22	2.46	4.05
14-16	2	5.57	4.03	2.56	4.05	5.00	3.74	3.30	4.01
	5	5.71	3.89	3.43	4.34	5.64	3.77	3.08	4.16
Average		5.64	3.96	2.99	4.20	5.32	3.75	3.19	4.09
Fertilizer—year average		5.85	4.40	2.86	4.37	5.74	4.38	2.76	4.29

dictate modification of management practices before irreversible changes develop. Accumulated root weights at the end of the second, third and fourth years of the test are given in Table 11.

The most significant point in this table is the reduction in root weight with each succeeding year. Neither clipping frequency nor nitrogen level significantly affected root weights. Average root accumulation with 5-inch stubble was 0.6 tons greater than with 2-inch stubble, which was significant statistically. The effect of clipping height was greatest with frequent harvest and decreased with less frequent harvest.

The accumulative effect of 4 years of differential clipping on root accumulation is shown in Figure 8. These results, obtained in the fall of the fourth year, do not show a consistent height effect, and no definite trend is associated with stage of maturity. Harvesting in advanced stages of maturity apparently does not greatly enhance root accumulation.

Sod density is important both for forage production and soil protection. Density was favored by the greater fertility rate and greater stubble height, but decreased with infrequent harvesting (Table 12). Average ground cover density generally increased each succeeding year of the test in contrast to root accumulation, which decreased, and yield, which was uniform from year to year.

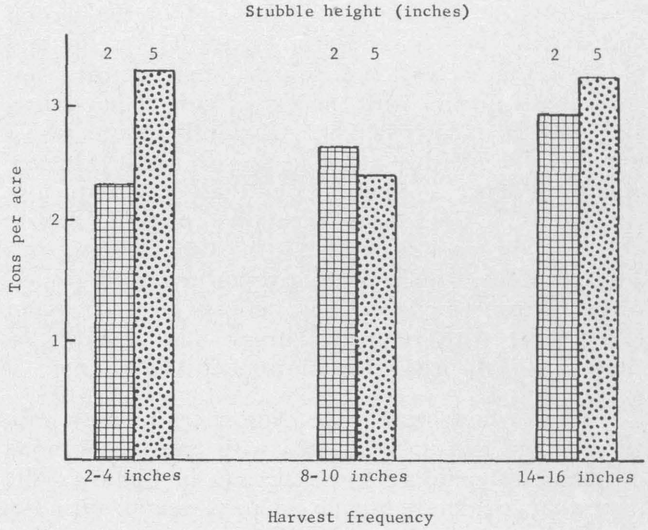

Figure 8. Coastal bermudagrass root accumulation following 4 years of differential clipping treatments.

Table 12. Density of Coastal bermudagrass with various fertilizer and clipping management practices at Mt. Pleasant, Texas, 3-year summary, 1962-64

Inches of top growth at harvest	Clipping height (inches)	Number of stems per square foot							
		120-60-60				240-60-60			
		1962	1963	1964	Average	1962	1963	1964	Average
2-4	2	183	256	331	257	222	248	268	246
	5	243	306	376	308	245	359	375	326
Average		213	281	354	283	234	304	322	286
8-10	2	192	169	234	198	198	248	259	235
	5	224	268	217	236	247	313	300	287
Average		208	219	225	217	223	281	280	261
14-16	2	177	178	174	176	218	204	178	200
	5	233	220	268	240	273	255	303	277
Average		205	199	221	208	246	230	241	239
Fertilizer—year average		209	233	267	236	234	272	281	262

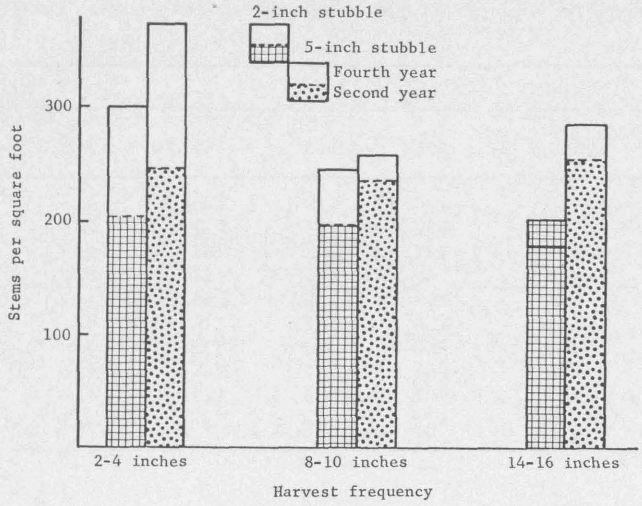

Figure 9. Sod density of Coastal bermudagrass following 2 and 4 years of differential clipping treatments.

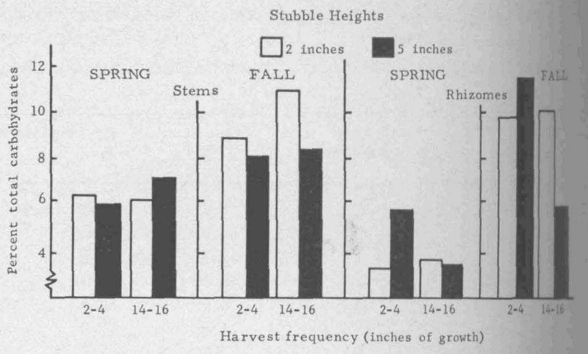

Figure 10. Carbohydrate content of Coastal bermudagrass stems and rhizomes following initiation of growth in the spring and at the end of the growing season.

The cumulative effect of differential cutting treatments on sod density at the end of the second and fourth years is shown in Figure 9. At the end of both the second and fourth years, density was consistently greater with the most frequent harvesting and with the greater height. Obviously, plants which were cut frequently tended to remain more prostrate and to produce a denser cover than less frequently cut plants. Also, more vegetative material would obviously be present with 5-inch stubble than with 2-inch stubble, which would give an increased ground cover. Density increased most between the second and fourth year with frequent harvest and actually decreased slightly with close, infrequent harvesting.

While there were some differences in both root weights and density associated with treatments, none of these differences were reflected in yields. The somewhat greater reduction in root weight with frequent close clipping could indicate some unfavorable cumulative effect of this management practice. However, the amount of roots at the end of the fourth year apparently is more than adequate to support a vigorous and productive stand.

Results of uniform harvests of all plots during the fifth year of the experiment indicated no residual effect of previous fertility levels on yield. Differences in yield associated with previous height of cutting were significant and favored 5-inch stubble. However, approximately 50 percent of the total yield in the fifth year consisted of crimson clover, and over 50 percent of the differences associated with previous height of cutting was in clover yields. Thus, differences in actual Coastal yield were small. Ground cover density at the end of the year of uniform treatments showed significant differences (.05 level) due to previous height of cutting, fertility level and stage of growth at harvest. Differences in ground cover were not related to yield except for the overall effect of height of cutting. Residual fertilizer effect on ground cover was a reversal of previous differences.

Numerous studies of the effects of clipping frequency on yield and stand productivity have been reported in the literature, but relatively few studies of clipping heights are found. The results of this study agree with most of those reported in the literature and indicate that height of cutting is much less important in bermudagrass production than frequency of defoliation.

Carbohydrate Content

Total carbohydrate (soluble carbohydrates plus starch) content of bermudagrass stems in the initial spring growth in 1964 was not influenced by previous treatment (Figure 10). Carbohydrate content (percent) of stems at the end of the growing season was higher from 2-inch than 5-inch stubble. Likely, the upper part of tall stubble was not active and was quite low in carbohydrates. Rhizomes were low in carbohydrates in early season, as might be expected, since reserves would have been depleted in the initiation of spring growth. Weimann (6) reported that bermudagrass rhizomes upon sprouting lost 80 to 90 percent of their total available carbohydrates. The fall carbohydrate content of roots in this study indicates satisfactory recovery. Root weights for the harvest frequencies cut at the same stubble height also were essentially equal at the end of the season. Thus, not only carbohydrate percentage but also the total amount of carbohydrates were influenced relatively little by harvest frequency. Stubble height did not appreciably influence carbohydrate percentage, but did influence total root weight, thereby influencing the total amount of available carbohydrates.

Both stem and rhizome samples were obtained in July, starting on the day of cutting and continuing

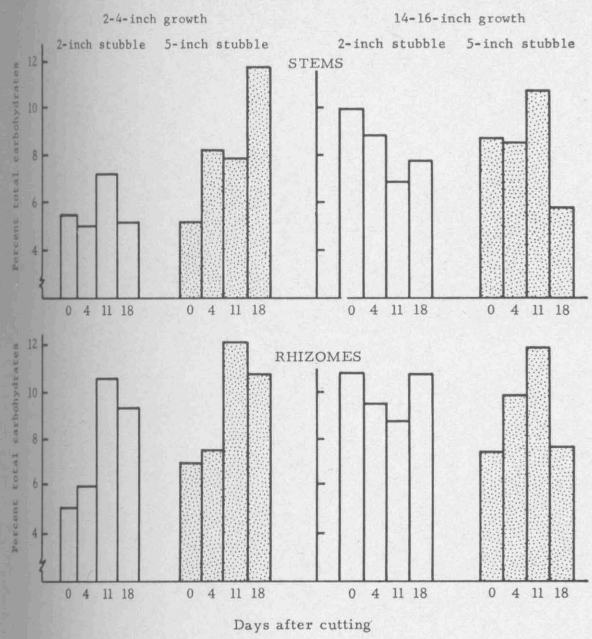

Figure 11. Carbohydrate content of Coastal bermudagrass stems and rhizomes at intervals following cutting in mid-summer.

for 18 days thereafter (Figure 11). The sampling period followed the third cutting of 2-4-inch frequency and the second cutting of 14-16-inch frequency. Effects of the more frequent harvesting are shown in the lower carbohydrate content of both stems and rhizomes from this treatment at the time sampling was started. Carbohydrates remained relatively low in 2-inch stems, which had been harvested more frequently, but within 11 to 18 days, the carbohydrate content of 5-inch stems and rhizomes from both heights was equivalent to that in less frequently harvested material. Stems and rhizomes from 2-inch clipping height and 14-16-inch frequency declined in carbohydrates through the first 11 days. No other treatment combination showed this pattern. Close, infrequent harvesting would have resulted in complete defoliation in contrast to close, frequent harvesting, which likely had greater leaf residual, thus allowing continued photosynthesis. The greater stubble would retain greater leaf area and also provide a greater total volume of storage to draw on; thus, it would not likely show the degree of depletion of short stubble.

Table 13. Mean maximum soil temperatures under Coastal bermudagrass sod, Mt. Pleasant, 1962-64

	Temperature — °F			
	Air	Stubble height (inches)		
Month	temperature	2[1]	2[2]	5[2]
June	89	90	88	87
July	95	97	93	91
August	95	96	93	90
September	84	87	85	80

[1]No nitrogen.

[2]120 pounds N per acre.

While clipping effects on the carbohydrate content of both stems and rhizomes were detectable in early season and immediately following clipping, the reserve status at neither the end of a growth cycle nor the end of the growing season reflected any permanent or sustained major treatment effects.

Soil Temperature

No attempt was made to evaluate the effect of the added ground cover of the 5-inch stubble on the soil itself except for soil temperature records. Average soil temperatures recorded 1 inch below the surface are shown in Table 13. Average daily high soil temperatures were highest under 2-inch stubble and no nitrogen and lowest under 5-inch stubble with nitrogen fertilization. While plant density measurements are not shown for the no-nitrogen plots, soil temperature effects are no doubt related to ground cover. The 5-inch stubble would have provided more shading than 2-inch stubble, and this is reflected in a lower maximum temperature.

Results of this study suggest that Coastal bermudagrass is tolerant to a wide range of management practices in terms of stand maintenance. Frequent cutting reduces yield, but apparently has little if any effect on stand maintenance. Height of cutting is much less important in Coastal bermudagrass production than either frequency of defoliation or level of fertilization. This study indicates that tall stubble is not necessary for the maintenance of Coastal bermudagrass and may actually result in slightly reduced yields, but the stubble may have other effects, either beneficial or detrimental, not evaluated in this study.

[Blank Page in Original Bulletin]

LITERATURE CITED

1. Burton, Glenn W. 1954. Coastal Bermuda for pasture, hay and silage. Georgia Agr. Exp. Sta. Bul. N.S. 2.

2. Burton, Glenn W. 1947. Breeding Bermudagrass for the southeastern states. Jour. Amer. Soc. Agron. 39:551-559.

3. Harlan, J. R., G. W. Burton and W. C. Elder. 1954. Midland Bermudagrass, a new variety for Oklahoma. Okla. Agri. Exp. Sta. Bul. 416.

4. USDA News Release—Suwannee Bermudagrass thrives on deep sand. Nov. 23, 1954.

5. Weinmann, H. 1961. Total available carbohydrates in grasses and legumes. Herb. Abstr. 31:255-261.

6. Wildman, Sam G. and Elmer Hansen. 1940. A semi-micro method for the determination of reducing sugars. Plant Physiol. 15:719-729.

Texas Agricultural Experiment Station

Texas A&M University
College Station, Texas 77843

H. O. Kunkel, Acting Director — Publication

Postage Paid
U. S. Department of Agric